REMARKS

In accordance with the foregoing, the specification and claims 23, 24, and 54 have been amended. Claims 1-64 are pending and under consideration.

ENTRY OF AMENDMENT UNDER 37 C.F.R. § 1.116:

Applicants request entry of this Rule 116 Response because the amendments of claims 1, 6, 12, 17, and 23 should not entail any further search by the Examiner since no new features are being added and no new issues are being raised; and the amendments do not significantly alter the scope of the claims and place the application at least into a better form for purposes of appeal. No new features or new issues are being raised.

The Manual of Patent Examining Procedures sets forth in Section 714.12 that "any amendment that would place the case either in condition for allowance or in better form for appeal may be entered." Moreover, Section 714.13 sets forth that "the Proposed Amendment should be given sufficient consideration to determine whether the claims are in condition for allowance and/or whether the issues on appeal are simplified." The Manual of Patent Examining Procedures further articulates that the reason for any non-entry should be explained expressly in the Advisory Action.

REJECTION UNDER 35 U.S.C. § 103:

In the Office Action, at page 2, claims 1-3 5-9, 11-20, and 22-64 were rejected under 35 U.S.C. § 103 in view of admitted prior art and U.S. Patent No. 5,966,399 to Jiang et al. ("Jiang"). The reasons for the rejection are set forth in the Office Action and therefore not repeated. The rejection is traversed and reconsideration is requested.

The Office Action correctly recognized that the admitted prior art failed to teach or suggest, "a micro-lens disposed in a window region through which the laser beam is emitted to collimate the laser beam across the entire window region; a lens layer formed on the upper reflector with a transparent material transmitting a laser beam, the lens layer comprising the micro-lens," as recited in independent claim 1.

Referring to Jiang, this reference provides a diffractive planar lens element 44 integrated with a device 10. See column 6, lines 43-45. The lens element 44 is integrated with the device 10 by etching into an uppermost surface, or layer, of a second stack 22 of distributed Bragg reflectors, a diffractive planar lens element. See column 6, lines 45-50. The Bragg reflectors have multiple ridges to reflect light. See FIGS. 1 and 2. Stacks 20 and 22 of distributed Bragg reflectors are formed by depositing pairs of alternating layers using some convenient technique such as molecular beam epitaxy (MBE) or sputtering. See column 4, lines 64-67. However, as further shown in FIGS. 2 and 3 of Jiang, the reference fails to teach or suggest providing the diffractive planar lens element 44 "in a window region through which the laser beam is emitted to collimate the laser beam **across the entire window region**," emphasis added, as recited in independent claim 1. Similarly to the admitted prior art of record, Jiang fails to teach or suggest, "a lens layer formed on the upper reflector with a transparent material transmitting a laser beam, the lens layer comprising the micro-lens," as recited in independent claim 1. Accordingly, it is respectfully requested that independent claim 1 and related dependent claims be allowed.

Referring to independent claim 6, the arguments presented above supporting the patentability of independent claim 1 are incorporated herein to support the patentability of independent claim 6. Furthermore, on page 4 of the Office Action, it is correctly recognized that the admitted prior art fails to teach or suggest "wherein the window region comprises a maximum width smaller than a size of light generated in the active layer emitted towards the window region, satisfying a Fraunhofer diffraction condition, where the Fraunhofer diffraction condition occurring in the window region is offset by a focusing power of the micro-lens," as recited in independent claim 6. However, the Office Action concludes, without adequate support that "since the combined structure of admitted prior art and Jiang is identical to the claimed device the combined structure satisfies the Fraunhofer diffraction condition as claimed." Neither the admitted prior art nor Jiang teaches or suggests a window region satisfying a Fraunhofer diffraction condition to, among other advantages, provide a VCSEL emitting a parallel laser beam, without including a separate condensing or a collimating lens. Specifically, the admitted prior art and Jiang, individually or combined, are **silent** as to providing "wherein the window region comprises a maximum width smaller than a size of light generated in the active layer emitted towards the window region, satisfying a Fraunhofer diffraction condition, where the Fraunhofer diffraction condition occurring in the window region is offset by a focusing power of the micro-lens," as recited in independent claim 6. In other words, even if the combination of the prior art of record were made, one would still not have the presently claimed invention without making yet further modifications to the suggested combination.

Independent claims 12 and 17 recite, "a micro-lens disposed in a window region through which a laser beam is emitted to collimate the laser beam across the entire window region; a substrate comprising a transparent material transmitting the laser beam, the substrate comprising the micro-lens." Further, independent claim 17 recites, "wherein the window region comprises a maximum width smaller than a size of the light generated in the active layer and emitted towards the window region, satisfying a Fraunhofer diffraction condition, where the Fraunhofer diffraction condition occurring in the window region is offset by a focusing power of the micro-lens."

Because these claimed features of independent claims 12 and 17 have been previously argued in support of the patentability of independent claims 1 and 6, the arguments presented above supporting the patentability of independent claims 1 and 6 are incorporated herein to support the patentability of independent claims 12 and 17.

Independent claim 23 recites "a micro-lens integrally formed on a laser beam emitting surface of the VCSEL and disposed in a window region through which a light beam is emitted to collimate the light beam across a window region to emit a parallel light beam." The arguments presented above supporting the patentability of independent claim 1 are incorporated herein to support the patentability of independent claim 23.

Because the prior art of record and Jiang, individually or combined, fail to teach or suggest the claimed features of independent claims 1, 6, 12, 17, and 23, it is respectfully asserted that the dependent claims corresponding independent claims 1, 6, 12, 17, and 23 are patentable in view of the prior art of record. Accordingly, it is respectfully requested that independent claims 1, 6, 12, 17, and 23 and related dependent claims be allowed.

In the Office Action, at page 14, claims 4, 10, and 21 were rejected under 35 U.S.C. § 103 in view of admitted prior art and U.S. Patent No. 6,122,109 to Peake et al. ("Peake"). The reasons for the rejection are set forth in the Office Action and therefore not repeated. The rejection is traversed and reconsideration is requested.

Dependent claims 4 and 10 depend from independent claim 1 and dependent claim 21 depends on independent claim 17. Accordingly, the cited references must teach or suggest, individually or combined, all the claimed features recited in independent claims 1 and 17. The arguments presented above supporting the patentability of independent claims 1 and 17 over the prior art of record are incorporated herein. Referring to Peake, this reference describes a microlens having very small focal length and a non-planar microstructure having a covering layer which is slowly oxidizing or substantially free of oxygen. See abstract. However, similarly to the prior art of record, Peake fails to teach or suggest, "a micro-lens disposed in a window region through which the laser beam is emitted to collimate the laser beam across the entire window region; a lens layer formed on the upper reflector with a transparent material transmitting a laser beam, the lens layer comprising the micro-lens," as recited in independent claim 1. Further, Peake fails to teach or suggest, "a micro-lens disposed in a window region through which a laser beam is emitted to collimate the laser beam across the entire window region; a substrate comprising a transparent material transmitting the laser beam, the substrate comprising the micro-lens . . . wherein the window region comprises a maximum width smaller than a size of the light generated in the active layer and emitted towards the window region, satisfying a Fraunhofer diffraction condition, where the Fraunhofer diffraction condition occurring in the window region is offset by a focusing power of the micro-lens," as recited in independent claim 17.

Because the prior art of record and Peake, individually or combined, fail to teach or suggest the claimed features of independent claims 1 and 17, it is respectfully asserted that the dependent claims 4, 10, and 21 corresponding to independent claims 1 and 17 are patentable in view of the cited prior art. Accordingly, it is respectfully requested that independent claims 1 and 17 and related dependent claims be allowed.

CONCLUSION:

In accordance with the foregoing, it is respectfully submitted that all outstanding objections and rejections have been overcome and/or rendered moot. And further, that all pending claims patentably distinguish over the prior art. Thus, there being no further outstanding objections or rejections, the application is submitted as being in condition for allowance which action is earnestly solicited. At a minimum, this Amendment should be entered at least for purposes of Appeal as it either clarifies and/or narrows the issues for consideration by the Board.

If the Examiner has any remaining issues to be addressed, it is believed that prosecution can be expedited and possibly concluded by the Examiner contacting the undersigned attorney for a telephone interview to discuss any such remaining issues.

If there are any underpayments or overpayments of fees associated with the filing of this Amendment, please charge and/or credit the same to our Deposit Account No. 19-3935.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

Please AMEND claims 1, 6, 12, 17, and 23 as follows. The remaining claims are reprinted, as a convenience to the Examiner, as they presently stand before the U.S. Patent and Trademark Office.

1. (ONCE AMENDED) A micro-lens built-in vertical cavity surface emitting laser (VCSEL) comprising:

a substrate;

a lower reflector formed on the substrate;

an active layer formed on the lower reflector, generating light by a recombination of electrons and holes;

an upper reflector formed on the active layer comprising a lower reflectivity than that of the lower reflector;

a micro-lens disposed in a window region through which the laser beam is emitted <u>to collimate the laser beam across the entire window region</u>;

a lens layer formed on the upper reflector with a transparent material transmitting a laser beam, the lens layer comprising the micro-lens;

an upper electrode formed above the upper reflector excluding the window region; and

a lower electrode formed underneath the substrate.

2. The micro-lens built in VCSEL as recited in claim 1, wherein the VCSEL satisfies a following relationship:

$$f = R \times n1/(n2 - n1)$$

where *f* is a distance along an optical axis from a light generating region of the active layer to a vertex of the micro-lens, R is a radius of curvature of the micro-lens, n1 is an effective refractive index of a medium on an optical path between the light generating region and the lens layer, and n2 is a refractive index of a region towards which a light is emitted through the micro-lens.

3. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 1, further comprising a high-resistance region between the upper and lower reflectors relatively close to the active layer, the high-resistance region having an aperture at a center thereof through which a current flows.

4. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 1, wherein the lens layer is formed of a material comprising at least one of silicon and a III-V compound semiconductor, wherein the III-V compound semiconductor comprises one of indium phosphide (InP), gallium arsenide (GaAs), indium arsenide (InAs), gallium phosphide (GaP), indium gallium phosphide (InGaP), indium gallium arsenide (InGaAs), and aluminum gallium arsenide (AlGaAs), the material comprising a relatively large bandgap to a wavelength of the laser beam so as not to absorb the laser beam.

5. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 1, wherein the micro-lens is formed by diffusion-limited etching.

6. (ONCE AMENDED) A micro-lens built-in vertical cavity surface emitting laser (VCSEL) comprising:

a substrate;

a lower reflector formed on the substrate;

an active layer formed on the lower reflector generating light by a recombination of electrons and holes;

an upper reflector formed on the active layer comprising a lower reflectivity than that of the lower reflector;

a micro-lens disposed in a window region through which the laser beam is emitted to collimate the laser beam across the entire window region;

a lens layer formed on the upper reflector with a transparent material transmitting a laser beam, the lens layer comprising the micro-lens;

an upper electrode formed above the upper reflector excluding the window region; and

a lower electrode formed underneath the substrate,

wherein the window region comprises a maximum width smaller than a size of light generated in the active layer emitted towards the window region, satisfying a Fraunhofer diffraction condition, where the Fraunhofer diffraction condition occurring in the window region is offset by a focusing power of the micro-lens.

7. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 6, wherein the maximum width of the window region D and a focal length *f* of the micro-lens satisfy a relation:

$$D = \sqrt{2 \times 1.22 \lambda f}$$

where λ is a wavelength of the laser beam emitted from the VCSEL.

8. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 6, further comprising a high-resistance region between the upper and lower reflectors, relatively close to the active layer, the high-resistance region comprising an aperture at a center thereof through which a current flows, the aperture of the high-resistance region comprising a maximum width greater than or approximately equal to the maximum width of the window region.

9. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 7, further comprising a high-resistance region between the upper and lower reflectors, relatively close to the active layer, the high-resistance region comprising an aperture at a center thereof through which a current flows, the aperture of the high-resistance region comprising a maximum width greater than or approximately equal to the maximum width of the window region.

10. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 4, wherein the lens layer is formed of a material comprising at least one of silicon and a III-V compound semiconductor, wherein the III-V compound semiconductor comprises one of indium phosphide (InP), gallium arsenide (GaAs), indium arsenide (InAs), gallium phosphide (GaP), indium gallium phosphide (InGaP), indium gallium arsenide (InGaAs), and aluminum gallium arsenide (AlGaAs), the material comprising a relatively large bandgap to a wavelength of the laser beam so as not to absorb the laser beam.

11. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 4, wherein the micro-lens is formed by diffusion-limited etching.

12. (ONCE AMENDED) A micro-lens built-in vertical cavity surface emitting laser (VCSEL) comprising:

a micro-lens disposed in a window region through which a laser beam is emitted to collimate the laser beam across the entire window region;

a substrate comprising a transparent material transmitting the laser beam, the substrate comprising the micro-lens;

a lower reflector formed on the substrate;

an active layer formed on the lower reflector, generating light by recombination of electrons and holes;

an upper reflector formed on the active layer comprising a higher reflectivity than that of the lower reflector;

an upper electrode formed on the upper reflector; and

a lower electrode formed on a portion of the substrate excluding the window region through which the laser beam is emitted.

13. (UNAMENDED) The micro-lens built in VCSEL as recited in claim 12, wherein the VCSEL satisfies a following relationship:

$$f = R \times n1/(n2 - n1)$$

where *f* is a distance along an optical axis from a light generating region of the active layer to a vertex of the micro-lens, R is a radius of curvature of the micro-lens, n1 is an effective refractive index of a medium on an optical path between the light generating region and the lens layer, and n2 is a refractive index of a region towards which a light is emitted through the micro-lens.

14. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 12, further comprising a high-resistance region between the upper and lower reflectors relatively close to the active layer, the high-resistance region having an aperture at a center thereof through which a current flows.

15. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 12, wherein the lens layer is formed of a material comprising at least one of silicon and a III-V compound semiconductor, wherein the III-V compound semiconductor comprises one of indium phosphide (InP), gallium arsenide (GaAs), indium arsenide (InAs), gallium phosphide (GaP), indium gallium phosphide (InGaP), indium gallium arsenide (InGaAs), and aluminum gallium arsenide (AlGaAs), the material comprising a relatively large bandgap to a wavelength of the laser beam so as not to absorb the laser beam.

16. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 12, wherein the micro-lens is formed by diffusion-limited etching.

17. (ONCE AMENDED) A micro-lens built-in vertical cavity surface emitting laser (VCSEL) comprising:

a micro-lens disposed in a window region through which a laser beam is emitted to collimate the laser beam across the entire window region;

a substrate comprising a transparent material transmitting the laser beam, the substrate comprising the micro-lens;

a lower reflector formed on the substrate;

an active layer formed on the lower reflector, generating light by recombination of electrons and holes;

an upper reflector formed on the active layer comprising a higher reflectivity than that of the lower reflector;

an upper electrode formed on the upper reflector; and

a lower electrode formed on a portion of the substrate excluding the window region through which the laser beam is emitted,

wherein the window region comprises a maximum width smaller than a size of the light generated in the active layer and emitted towards the window region, satisfying a Fraunhofer diffraction condition, where the Fraunhofer diffraction condition occurring in the window region is offset by a focusing power of the micro-lens.

18. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 17, wherein the maximum width of the window region D and a focal length *f* of the micro-lens satisfy a relation:

$$D = \sqrt{2 \times 1.22 \lambda f}$$

where λ is a wavelength of the laser beam emitted from the VCSEL.

19. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 17, further comprising a high-resistance region between the upper and lower reflectors positioned relatively close to the active layer, the high-resistance region comprising an aperture at a center thereof through which a current flows, where the aperture of the high-resistance region comprises a maximum width greater than or approximately equal to the maximum width of the window region.

20. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 18, further comprising a high-resistance region between the upper and lower reflectors positioned relatively close to the active layer, the high-resistance region comprising an aperture at a center thereof through which a current flows, where the aperture of the high-resistance region comprises a maximum width greater than or approximately equal to the maximum width of the window region.

21. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 17, wherein the

lens layer is formed of a material comprising at least one of silicon and a III-V compound semiconductor, wherein the III-V compound semiconductor comprises one of indium phosphide (InP), gallium arsenide (GaAs), indium arsenide (InAs), gallium phosphide (GaP), indium gallium phosphide (InGaP), indium gallium arsenide (InGaAs), and aluminum gallium arsenide (AlGaAs), the material comprising a relatively large bandgap to a wavelength of the laser beam so as not to absorb the laser beam.

22. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 18, wherein the micro-lens is formed by diffusion-limited etching.

23. (TWICE AMENDED) A micro-lens built-in vertical cavity surface emitting laser (VCSEL), comprising:

a micro-lens integrally formed on a laser beam emitting surface of the VCSEL [emitting a parallel light beam] and disposed in a window region through which [the] <u>a</u> light beam is emitted <u>to collimate the light beam across a window region to emit a parallel light beam</u>;

a lens layer comprising the micro-lens and formed on the laser beam emitting surface of the VCSEL; and

an upper electrode formed on a portion of the lens layer excluding the window region.

24. (as ONCE AMENDED) The micro-lens built-in VCSEL as recited in claim 23, further comprising:

a substrate;

a lower electrode formed underneath the substrate;

a lower reflector;

an active layer comprising a light generating region; and

an upper reflector comprising a relatively lower reflectivity than that of the lower reflector, wherein the window region is defined by the upper electrode and the micro-lens.

25. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 24, wherein the first focal point of the micro-lens is positioned in the light generating region of the active layer, so that the light beam generated in a narrow light generating region is incident on and condensed by the micro-lens, and is emitted as the parallel light beam.

26. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 24, further

comprising:

a high-resistance region between the upper and lower reflectors relatively close to the active layer, the high-resistance region having an aperture at a center thereof through which a current flows comprising a maximum width greater than or approximately equal to the maximum width of the window region.

27. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 26, wherein the aperture is small where the current applied through the upper electrode passes a region on the active layer and the light beam is generated in a dot-sized region of the active layer.

28. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 23, wherein the micro-lens lies along a central optical axis of the light beam emitted from the VCSEL.

29. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 24, wherein the lower reflector, the active layer, and the upper reflector are sequentially stacked on the substrate.

30. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 24, wherein the substrate is formed of a semiconductor material comprising n-doped gallium arsenide (GaAs), aluminum gallium arsenide (AlGaAs), indium arsenide (InAs), indium phosphide (InP), gallium phosphide (GaP), indium gallium phosphide (InGaP), indium gallium arsenide (InGaAs), or gallium phosphide (GaP), the material comprising a relatively large bandgap to a wavelength of the laser beam so as not to absorb the laser beam.

31. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 24, wherein the lower reflector and the upper reflector are formed of alternating semiconductor compounds comprising different refractive indexes.

32. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 24, wherein the substrate is doped with n-type impurities, the lower reflector is doped with the same n-type impurities and the upper reflector is doped with p-type impurities.

33. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 24, wherein the active layer is formed of GaAs, AlGaAs, InGaAs, InGaP and/or AlGaAsP according to a wavelength of the light beam.

34. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 24, further comprising:

a high-resistance region comprising an aperture at a center thereof through which current applied through the upper electrode flows and high-resistance region is formed by implantations of ions or by selective oxidation in a region of the upper reflector.

35. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 24, wherein the lens layer comprises a thickness of several micrometers and is formed of a material having a relatively wide bandgap to a wavelength of the light beam generated from the VCSEL.

36. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 23, wherein the micro-lens comprises a convex surface formed by diffusion-limited etching.

37. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 24, wherein the upper electrode is formed on the lens layer or between the upper reflector and the lens layer.

38. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 24, wherein a distance along an optical axis from the light generating region to a vertex of the micro-lens is equal to a focal length of the micro-lens.

39. (UNAMENDED) The micro-lens built in VCSEL as recited in claim 38, wherein the VCSEL satisfies a following relationship:

$$f = R \times n1/(n2 - n1)$$

where *f* is a distance along an optical axis from the light generating region to the vertex of the micro-lens, *R* is a radius of curvature of the micro-lens, *n1* is an effective refractive index of a medium on an optical path between the light generating region and the lens layer, and *n2* is a refractive index of a region toward which the light beam is emitted through the micro-lens.

40. (UNAMENDED) The micro-lens built in VCSEL as recited in claim 38, wherein the VCSEL satisfies a following relationship:

$$n1/S1 + n2/S2 = (n2 - n1)/R$$

where S1 is a distance from the light generating region of the active layer to a vertex of the micro-lens on the optical axis, S2 is a distance from the vertex of the micro-lens to a second focal point of the micro-lens, n1 is an effective refractive index of the medium from the upper reflector and the lens layer, and n2 is a refractive index of a region toward which the light beam emitted through the micro-lens travels.

41. (UNAMENDED) The micro-lens built in VCSEL as recited in claim 24, wherein as a forward biased current is applied to the micro-lens built-in VCSEL through the upper and lower electrodes, the light beam comprising a particular wavelength through laser oscillation is transmitted through the upper reflector and the lens layer and is condensed by the micro-lens and emitted as the parallel laser beam.

42. (UNAMENDED) The micro-lens built in VCSEL as recited in claim 23, wherein the VCSEL is a top-emitting type VCSEL.

43. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 23, further comprising:

a substrate, wherein the micro-lens is formed in the window region of the substrate through which the light beam is condensed and emitted;

a lower reflector;

an active layer comprising a light generating region;

an upper reflector comprising a higher reflectivity than that of the lower reflector;

a lower electrode formed underneath the substrate excluding a window region through which the light beam is emitted; and

an upper electrode formed on the upper reflector, wherein the window region is defined by the lower electrode and the micro-lens.

44. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 43, wherein a first focal point of the micro-lens is positioned in the light generating region of the active layer, where the light beam generated in a narrow light generating region is incident on and condensed by the micro-lens, and is emitted as the parallel light beam.

45. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 43, further comprising:

a high-resistance region between the upper and lower reflectors relatively close to the active layer, the high-resistance region comprising an aperture at a center thereof through which a current flows comprising a maximum width greater than or approximately equal to the maximum width of the window region.

46. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 43, wherein the lower reflector, the active layer, and the upper reflector are sequentially stacked on the substrate.

47. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 43, wherein when a number of stacked layers of the lower reflector is smaller than that of the upper reflector, the reflectivity of the lower reflector is lower than that of the upper reflector and most of the laser beam is emitted through the lower reflector.

48. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 43, wherein the substrate is formed of a semiconductor material comprising n-doped gallium arsenide (GaAs), aluminum gallium arsenide (AlGaAs), indium arsenide (InAs), indium phosphide (InP), gallium phosphide (GaP), indium gallium phosphide (InGaP), indium gallium arsenide (InGaAs), or gallium phosphide (GaP).

49. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 43, wherein the lower reflector and the upper reflector are formed of alternating semiconductor compounds comprising different refractive indexes.

50. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 43, wherein the substrate comprises a material having a relatively wide bandgap compared to a wavelength of the light beam generated from the VCSEL, so as not to absorb, but transmit the laser beam incident from the lower reflector.

51. (UNAMENDED) The micro-lens built in VCSEL as recited in claim 43, wherein the VCSEL satisfies a following relationship:

$$f' = R' \times n1' / (n2' - n1')$$

where R′ is a radius of curvature of the micro-lens, n1′ is a effective refractive index of a medium along an optical path between the light generating region of the active layer and the micro-lens, and n2′ is a refractive index of a region toward which the light beam emits through the micro-lens, f′ is a distance from the light generating region to a vertex of the micro-lens along the optical axis.

52. (UNAMENDED) The micro-lens built in VCSEL as recited in claim 43, wherein as a forward biased current is applied to the micro-lens built-in VCSEL through the upper and lower electrodes, a laser beam comprising a particular wavelength through laser oscillation is transmitted through the lower reflector and the substrate and is condensed by the micro-lens and emitted as the parallel laser beam.

53. (UNAMENDED) The micro-lens built in VCSEL as recited in claim 43, wherein the VCSEL is a bottom-emitting type VCSEL.

54. (as ONCE AMENDED) The micro-lens built-in VCSEL as recited in claim 23, further comprising:

a substrate;

a lower electrode formed underneath the substrate;

a lower reflector;

an active layer comprising a light generating region; and

an upper reflector comprising a relatively lower reflectivity than that of the lower reflector, wherein the window region comprises a diameter sa0tisfying a Fraunhofer diffraction condition and is defined by the upper electrode and the micro-lens.

55. (UNAMENDED) The micro-lens built in VCSEL as recited in claim 54, wherein the window region comprises a maximum width smaller than a size of the light beam generated in the active layer emitted towards the window region.

56. (UNAMENDED) The micro-lens built in VCSEL as recited in claim 54, wherein the Fraunhofer diffraction condition of the window is offset by a focusing power of the micro-lens so that a parallel laser beam is emitted through the micro-lens.

57. (UNAMENDED) The micro-lens built in VCSEL as recited in claim 56, wherein the diameter D of the window and a focal length f of the micro-lens satisfy a following relationship:

$$D = \sqrt{2 \times 1.22 \lambda f}$$

where λ is a wavelength of the light beam emitted from the VCSEL.

58. (UNAMENDED) The micro-lens built-in VCSEL as recited in claim 54, further comprising a high-resistance region between the upper and lower reflectors relatively close to the active layer, the high-resistance region comprises an aperture at the center thereof through which a current flows.

59. (UNAMENDED) The micro-lens built in VCSEL as recited in claim 58, wherein the diameter of the window is smaller than or approximately equal to a diameter of the aperture of the high-resistance region.

60. (UNAMENDED) The micro-lens built in VCSEL as recited in claim 54, wherein the window and the micro-lens are positioned on a same plane.

61. (UNAMENDED) The micro-lens built in VCSEL as recited in claim 54, wherein the Fraunhofer diffraction condition satisfies a following relationship:

$$N_f = \frac{D^2}{\lambda d} << 1$$

where N_f is a Fresnel number, λ is a wavelength of the light beam emitted from the VCSEL, D is the diameter of the window, and *d* is a distance from the window to an observing plane, which is one focal point of the micro-lens.

62. (UNAMENDED) The micro-lens built in VCSEL as recited in claim 54, wherein the micro-lens is positioned in front or behind the window or the micro-lens and the window are positioned on a same plane.

63. (UNAMENDED) The micro-lens built in VCSEL as recited in claim 54, wherein when the micro-lens and the window are positioned on a same plane and only a 0^{th}-order diffracted beam comprising a high intensity is considered, a radius R_s of the 0^{th}-order diffracted beam satisfies a following relationship:

$$R_s = \frac{1.22\lambda d}{D}$$

where λ is a wavelength of the light beam emitted from the VCSEL, D is the diameter of the window, and d is a distance from the window to an observing plane.

64. (UNAMENDED) The micro-lens built in VCSEL as recited in claim 54, wherein the VCSEL is a top-emitting type VCSEL.